

# Electronic Equipment Manufacturing

(SIC 357, 365, 366, 367, 381)

## SIGNIFICANT POINTS

- Rapid technological change and intense competition make research and development efforts the key to success.
- Employment prospects are good for highly skilled technical personnel, but employment of production workers will grow slowly.

### Nature of the Industry

The electronic equipment manufacturing industry produces computers, television sets, and audio equipment, as well as a wide range of goods used for both commercial and military purposes. In addition, many electronics products or components are incorporated into other industries' products, such as cars, toys, watches, appliances, and a variety of electronic gadgets.

Technological innovation characterizes this industry almost unlike any other and, in fact, drives much of the industries' production. On the horizon are many products, including loudspeakers that can be heard but not seen, photographs stored on (and viewed from) CDs, and computers that can recognize voices.

Products currently being manufactured in this industry include computers and computer storage devices such as disk drives and computer peripheral equipment such as printers and scanners. The industry also produces calculating and accounting machines such as automated teller machines (ATM's); communications equipment such as telephone switching equipment and cellular telephones; consumer electronics, such as television and stereo sets; and military electronics such as radar, sonar, missile guidance systems, and electronic warfare equipment. This industry also includes the manufacture of semiconductors—silicon or computer “chips,” or integrated circuits—which are the heart of computers and many other advanced electronic products. Two of the most significant types of computer chips are microprocessors, which comprise the central processing system of computers, and memory chips, which store information.

This industry differs from other manufacturing industries in that production workers account for a much lower proportion of all workers. The unusually rapid pace of innovation and technological advancement requires a high proportion of engineering and technical workers to continually develop and produce new products. American companies manufacture and assemble many products abroad because of lower production costs and new trade agreements. However, the growing complexity of some of the most highly technical production processes—in semiconductor and electronic component manufacturing in particular—is leading to increased demand for a more highly skilled workforce in the United States.

Companies producing components, intermediate, and finished goods frequently cluster near each other because it allows easier access to recent innovations. Electronic products contain many components—and sometimes even major parts, such as integrated circuits—which often are purchased from

other manufacturers. As a result of having the skilled workforce that fosters product improvement, some areas of the country have become centers of the electronics industry. The most prominent of these centers is “Silicon Valley,” a concentration of integrated circuit and computer firms in California's Santa Clara valley near San Jose. Other emerging centers are in Texas, Massachusetts, and more recently Oregon. There are, however, electronics manufacturing plants throughout the country.

To a large extent, electronics manufacturing has become truly global, and it is difficult to characterize many companies and their products as American or foreign. The movement of foreign companies to manufacture some goods in the United States does not change the fact that many products are being designed in one country, manufactured in another, and assembled in a third. Highly sensitive and sophisticated products such as semiconductors and computers are being designed and manufactured in the United States, for example, but it remains likely that other parts of final products such as the keyboards and outer casings are made somewhere else and shipped to another site for final assembly.

Although some of the companies in this industry are large, most are actually small. The history of innovation in the industry explains the start-up of many small firms. Some companies are involved in design or research and development (R&D), whereas others may simply manufacture components such as computer chips under contract for others. Often an engineer or physicist will have an innovative idea and set up a new company to develop the product. Although electronic products can be very sophisticated, it has been possible to manufacture many electronic products or components (not necessarily finished products) with a relatively small investment. Furthermore, investors often are willing to put their money behind new companies in this industry because of its history of large paybacks from some very successful companies. Such success depends on innovation, and, although investment costs are rising, there should continue to be opportunities to develop good ideas.

The rapid pace of innovation in electronics technology makes for a constant demand for newer and faster products and applications. This demand puts a greater emphasis on research and development (R&D) than is typical in most manufacturing operations. Being the first firm to market a new or better product usually determines the success or failure of the product and often the company. Even for many relatively commonplace items, R&D continues to result in better, cheaper products with more desirable features. For

example, a company that develops a new kind of computer chip to be used in many brands of computers can earn millions of dollars in sales until a competitor is able to copy the technology or develop a better chip. Many employees, therefore, are research scientists, engineers, and technicians whose job it is to continually develop and improve products.

The product design process includes not only the initial design, but also development work which ensures that the product functions properly and can be manufactured as inexpensively as possible. When a product is manufactured, the components are assembled, usually by soldering them to a printed circuit board. Often tedious, hand assembly requires both good eyesight and coordination, as many of the parts are very small. However, because of the cost and precision involved, assembly and packaging are becoming highly automated.

### Working Conditions

In general, electronics manufacturing enjoys relatively good working conditions, even for production workers. In contrast to many other manufacturing industries, production workers in this industry usually work in clean and relatively noise-free environments. Computer chips are manufactured in "clean rooms," in which the air is filtered and workers wear special garments to prevent any dust from getting into the air. A speck of dust will ruin a computer chip.

In 1997, the rates of work-related injuries and illness per 100 full-time workers were 3.0 per 100 full-time workers in computer and office equipment, 3.7 in communications equipment, 5.0 in electronic components and accessories, 6.9 in household audio and video equipment, and 2.2 in search and navigation equipment. These rates were all lower than the 7.1 average for the private sector. However, some jobs in this industry may have risks. For example, some workers who fabricate integrated circuits and other components may be exposed to potentially hazardous chemicals, and working with small parts may cause eyestrain.

Most employees work regular 40-hour weeks, but pressure to develop new products ahead of competitors may result in some research and development personnel working extensive overtime to meet deadlines. The competitive nature of the industry makes for an exciting, but sometimes stressful, work environment—especially for those in technical and managerial occupations.

### Employment

The electronic equipment manufacturing industry employed about 1.6 million wage and salary workers in 1998 (table 1). Few workers were self-employed.

**Table 1. Distribution of wage and salary employment in electronic equipment manufacturing by industry segment, 1998**

| Industry segment                          | Employment<br>(in thousands) | Percent |
|---|------------------------------|---------|
| Total, electronic equipment manufacturing | 1,564                        | 100.0   |
| Electronic components and accessories ... | 666                          | 42.6    |
| Computer and office equipment .....       | 379                          | 24.2    |
| Communication equipment .....             | 282                          | 18.0    |
| Search and navigation equipment.....      | 162                          | 10.4    |
| Household audio and video equipment...    | 82                           | 5.2     |

The industry comprised about 13,000 establishments in 1997, many of which were small, employing only 1 or a few workers. Large establishments of 250 workers or more employed the majority—70 percent—of the industry's workforce (chart).

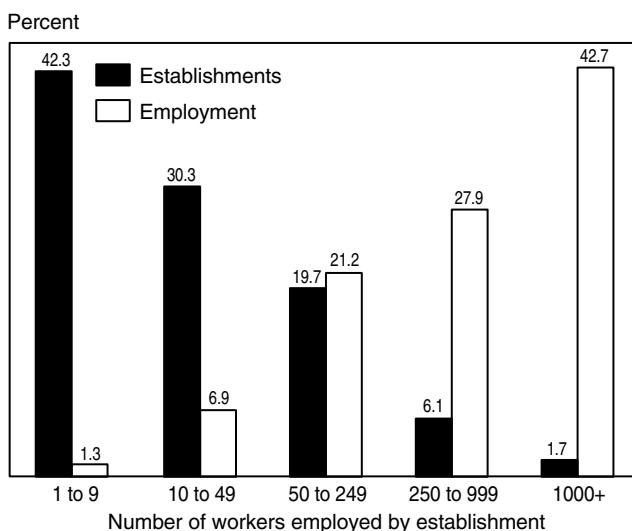
### Occupations in the Industry

Given the importance of R&D to the industry, it is not surprising that a large proportion—about 1 in 5—of all workers are in professional specialty occupations (table 2). Over 50 percent of these are engineers—mainly *electrical and electronics engineers* and *computer engineers*. These workers develop new products and devise better, more efficient production methods. Engineers may coordinate and lead teams developing new products. Others may work with customers to help them make the best use of the products. A growing number of *computer systems analysts* and *computer scientists* are being employed throughout the industry as both development and production methods become more computerized. Other professionals include *mathematical and physical scientists*, and *technical writers*.

About 8 percent of workers are technicians—mostly *engineering technicians*—many of who work closely with engineers. They help develop new products, work in production areas, and sometimes help customers install, maintain and repair equipment. They also may test new products or processes to make sure everything works correctly.

Despite the relatively high proportion of professional and technical workers in electronics manufacturing, more than 4 out of 10 workers are production workers. Many are assemblers, who place and solder components on circuit boards, or assemble and connect the various parts of electronic devices. *Electronic semiconductor processors* initiate and control the many automated steps in the process of manufacturing of integrated circuits or computer chips. *Electrical and electronic assemblers* are responsible for putting together products such as computers and appliances, telecommunications equipment, and even missile control systems. *Precision assemblers* must be able to do accurate work at a rapid

**Though most electronics firms are small, employment is concentrated in large establishments**



Source: U.S. Department of Commerce, *County Business Patterns*, 1997

pace. Some assemblers are highly skilled and require significant experience and training to assemble major components. A skilled assembler may put together an entire subassembly or even an entire product, especially when products are made in relatively small numbers. Other less skilled assemblers often work on a production line, attaching one or a few parts and continually repeating the same operation. Increasingly, as production work becomes more automated, assemblers and other production workers monitor the machinery which actually does the assembly work. *Precision inspectors, testers, and graders* use sophisticated testing machinery to ensure devices operate as designed.

About 14 percent of workers in the industry are in executive, administrative, and managerial occupations. In this industry, top management is much more likely to have a technical background than in other industries, especially in smaller companies, which often are founded by engineers, computer scientists, or other technical professionals.

About 13 percent of workers in this industry hold administrative, clerical, or sales jobs. Sales positions require technical knowledge and abilities, and as a result, engineers and technicians often may find opportunities in sales or sales support.

### Training and Advancement

Workers with varying levels of education find employment opportunities in the electronic equipment manufacturing industry. Entry to engineering occupations generally requires at least a bachelor's degree in engineering, although those with 4-year degrees in physical science or computer science or other technical areas can sometimes qualify as well. Some positions, however, may require a master's degree or higher or relevant work experience. Computer systems analysts or scientists usually need a degree in computer science or a related field, and in many cases, they also must have considerable programming experience. Since companies are often founded by professionals with technical backgrounds, opportunities for advancement into executive, administrative, and managerial positions may arise for experienced workers who keep up with rapid changes in technology.

Training for engineering technicians is available from a number of sources. Although most employers prefer graduates of 2-year postsecondary training schools—usually technical institutes or junior colleges—training in the Armed Forces or through proprietary schools may also meet employer requirements. Engineering technicians, like engineers, should have an aptitude for math and science. Entry level technicians may begin working with a more experienced technician or engineer. Advancement opportunities for experienced technicians may include supervisory positions or movement into other production and inspection operations.

Though assembly workers generally need only a high school diploma, assemblers in the electronics industry may need more specialized training or experience than workers in other manufacturing industries. Precision assembly work can be extremely sophisticated and complex, and some precision assembly jobs even may require formal technical training. Again, advancement opportunities depend not only on work experience, but also the level of technical training and the ability to keep up with changing technology.

**Table 2. Employment of wage and salary workers in electronic equipment manufacturing by occupation, 1998 and projected change, 1998-2008**

(Employment in thousands)

| Occupation  | 1998                 |         | 1998-2008<br>Percent<br>change |
|---|----------------------|---------|--------------------------------|
|   | Employment<br>Number | Percent |                                |
| <b>All occupations</b> .....  | 1,564                | 100.0   | 8.8                            |
| <b>Operators, fabricators, and laborers</b> .....                                 | 370                  | 23.6    | 19.1                           |
| Electrical and electronic assemblers .....  | 124                  | 7.9     | 18.0                           |
| Electronic semiconductor processors .....   | 62                   | 4.0     | 46.3                           |
| All other assemblers, fabricators, and hand workers .....                         | 46                   | 3.0     | 9.9                            |
| Helpers, laborers, and material movers, hand .....                                | 19                   | 1.2     | -2.5                           |
| <b>Professional specialty</b> .....   | 328                  | 21.0    | 14.9                           |
| Electrical and electronics engineers .....  | 102                  | 6.5     | 14.5                           |
| Computer engineers .....  | 44                   | 2.8     | 10.9                           |
| Computer support specialists .....  | 26                   | 1.7     | 37.6                           |
| Industrial engineers .....  | 17                   | 1.1     | -1.7                           |
| Mechanical engineers .....  | 15                   | 1.0     | 12.2                           |
| <b>Precision production, craft, and repair</b> .....                              | 315                  | 20.1    | 4.8                            |
| Electrical and electronic equipment assemblers, precision .....                   | 117                  | 7.5     | 7.7                            |
| Inspectors, testers, and graders, precision .....                                 | 57                   | 3.6     | -12.9                          |
| Mechanics, installers, and repairers .....  | 43                   | 2.7     | 9.6                            |
| Blue-collar worker supervisors .....  | 43                   | 2.7     | 10.6                           |
| Industrial machinery mechanics .....  | 17                   | 1.1     | 14.7                           |
| Metal workers, precision .....  | 15                   | 1.0     | 9.7                            |
| <b>Executive, administrative, and managerial</b> .....                            | 219                  | 14.0    | 4.4                            |
| Engineering, natural science, and computer and information systems managers ..... | 28                   | 1.8     | 22.8                           |
| General managers and top executives .....   | 27                   | 1.7     | 3.0                            |
| Industrial production managers .....  | 18                   | 1.1     | 1.5                            |
| Purchasing agents, except wholesale, retail, and farm products .....              | 17                   | 1.1     | 6.2                            |
| Accountants and auditors .....  | 16                   | 1.0     | -3.8                           |
| <b>Administrative support, including clerical</b> .....                           | 157                  | 10.1    | -5.6                           |
| Secretaries .....   | 28                   | 1.8     | -17.2                          |
| Production, planning, and expediting clerks .....                                 | 18                   | 1.2     | -4.1                           |
| Shipping, receiving, and traffic clerks .....                                     | 15                   | 1.0     | 1.3                            |
| General office clerks .....   | 14                   | 0.9     | 7.0                            |
| Financial records processing occupations .....                                    | 14                   | 0.9     | -12.0                          |
| <b>Technicians and related support</b> .....                                      | 122                  | 7.8     | -0.5                           |
| Electrical and electronics technicians and technologists .....                    | 61                   | 3.9     | 2.5                            |
| All other engineering technicians and technologists .....                         | 28                   | 1.8     | 8.7                            |
| Computer programmers .....  | 20                   | 1.3     | -19.8                          |
| <b>Marketing and sales</b> .....  | 42                   | 2.7     | 5.9                            |
| <b>All other occupations</b> .....  | 12                   | 0.7     | 0.7                            |

## Earnings

In general, earnings in the electronics industry are high, although this is partly because many of the lower wage production jobs have been automated or exported to other countries. Average weekly earnings of all production or nonsupervisory workers in the industry in 1998 were higher than the average of \$442 for all industries (table 3).

**Table 3. Average earnings of nonsupervisory workers in the electronic equipment manufacturing industry, 1998**

| Industry segment                            | Weekly | Hourly  |
|---|--------|---------|
| Total, private industry .....               | \$442  | \$12.77 |
| Electronics industry                        |        |         |
| Search and navigation equipment .....       | 733    | 17.32   |
| Computer and office equipment .....         | 640    | 15.32   |
| Communications equipment .....              | 596    | 14.02   |
| Electronic components and accessories ..... | 549    | 13.25   |
| Household audio and video equipment .....   | 485    | 11.94   |

Earnings in selected occupations in several components of the electronic equipment manufacturing in 1997 appear in table 4.

**Table 4. Median hourly earnings of the largest occupations in electronic equipment manufacturing, 1997**

| Occupation  | Computer and office equipment | Household audio and video equipment | Communications equipment | Electronic components and accessories |
|---|-------------------------------|-------------------------------------|--------------------------|---------------------------------------|
| Electrical and electronic engineers .....   | \$32.24                       | —                                   | \$28.55                  | \$28.78                               |
| Computer engineers .....  | 30.63                         | —                                   | 28.41                    | 29.62                                 |
| Electrical and electronic engineering technicians and technologists .....               | 15.88                         | —                                   | 15.30                    | 18.44                                 |
| Electrical and electronic equipment assemblers, precision .....                         | 11.24                         | \$9.68                              | 9.94                     | 8.70                                  |
| Electrical and electronic assemblers .....  | 8.85                          | 8.79                                | 8.70                     | 8.24                                  |
| First-line supervisors and managers/supervisors-production and operating workers .....  | —                             | —                                   | 15.80                    | 16.58                                 |
| Electronic semiconductor processors .....   | —                             | —                                   | —                        | 11.73                                 |
| Precision Inspectors, testers, and graders .....  | —                             | —                                   | —                        | 10.31                                 |
| Production inspectors, testers, graders, sorters, samplers, and weighers .....          | —                             | —                                   | 10.78                    | 10.39                                 |
| Assemblers and fabricators, except machine, electrical, electronic, and precision ..... | 8.97                          | —                                   | —                        | —                                     |

## Outlook

The revolutions taking place in computers, semiconductors, and telecommunications should provide workers in many of the industry's occupations with employment opportunities, especially in research and development. Breakthroughs in telephone, navigational, and household audio and video equipment will have a major impact on the workplace and in

homes. Products of the electronic equipment manufacturing industry, especially powerful computer chips, will continue to enhance productivity in all areas of the economy. Overall employment is projected to grow by about 9 percent between 1998 and 2008. The industry is expected to continue its rapid productivity growth, so even though output is expected to increase in most segments as global demand for electronics products rises, employment of production workers will not grow as quickly, and is actually expected to decline in some segments.

Expected employment growth varies by industry segment (table 5). Demand for computers should remain strong worldwide, but new technology and automated manufacturing processes should continue to eliminate jobs. This trend is also true in the areas of household audio and video equipment, and to some extent search and navigation equipment; these industry segments are using the same technology to automate production of increasingly sophisticated equipment. In addition, labor-intensive manufacturing, assembly, and packaging operations are still being moved to low-wage countries in the Far East or to Mexico when cost effective, although this strategy grows less attractive as the technical demands of manufacturing become more complex. In addition, the need for manufacturing to be located near the research site may help to moderate the move abroad.

Employment in electronic components and accessories, on the other hand, is expected to grow faster than the average over the projection period, more than offsetting expected declines in other segments. The market for semiconductors is growing tremendously and as a result, the need for skilled labor has been increasing worldwide. As chips become smaller and more powerful and production processes more sophisticated, the size of the U.S. market, coupled with the need for a strong infrastructure and highly skilled workforce, has shifted focus back to the U.S. in this segment of the industry.

**Table 5. Projected employment change in electronics manufacturing by industry segment, 1998-2008**

| Industry segment                                | Percent change |
|---|----------------|
| Total, electronic equipment manufacturing ..... | 8.8            |
| Electronic components and accessories .....     | 24.2           |
| Communications equipment .....                  | 7.3            |
| Computer and office equipment .....             | -2.8           |
| Search and navigation equipment .....           | -11.5          |
| Household audio and video equipment .....       | -17.3          |

Demand for communications equipment, such as cellular phones, should result in employment growth in the industry. Ownership of cellular phones has grown quickly in recent years; continuing improvements in quality and services should lead to even greater growth between 1998 and 2008. As cellular phones change over to digital technology, they will allow users to browse the Internet away from a desk. In addition, a substantial increase in baud speeds for these phones will raise their attractiveness to businesses that have had to rely on desktop PCs with their much faster speeds.

With respect to "wired" communications, the replacement of existing forms of wire—in buildings, airplanes, and underground—with more technologically advanced fiber optics also

will contribute to demand for workers in the communications segment of electronic equipment manufacturing.

Much of the employment growth in this industry is expected to be among the professional specialty occupations. Electronic semiconductor processors and electrical and electronic assemblers will also grow faster than the industry average. Highly skilled technical personnel should be able to take advantage of the increasingly sophisticated level of manufacturing technology as industries become more integrated and development and manufacturing processes more advanced. Employment of production workers is expected to grow more slowly than the industry as a whole, as more jobs are lost to technological innovation. Overall, employment of managers is also expected to grow slower than the average while clerical occupations are expected to decline.

The electronics industry is characterized by rapid technological advances and has grown faster than most other industries over the past 30 years, although rising capital costs and the rapid pace of innovation continue to pose challenges. Certain segments and individual companies often are subject to problems. For example, the computer industry occasionally undergoes severe downturns, and individual companies can run into trouble—even those in segments of the industry doing well—because they have not kept up with the latest technological developments or because they have erred in deciding which products to manufacture. Such uncertainties can be expected to continue. In addition, foreign competition and the future role of imports remain difficult to project. Import competition has wiped out major parts of the domestic consumer electronics industry, and future effects of import competition are dependent on trade policies and market forces. The industry is likely to continue to encounter strong competition from imported electronic goods and components, especially from Japan, but also from other countries throughout Asia and Europe.

Sales of military electronics, an important segment of the industry, will likely decline as defense expenditures decrease. On the other hand, it is likely that firms will continue developing new products, creating large new markets as they have in the past. Smaller, more powerful computer chips are continually being developed and incorporated into

an even wider array of products, and the semiconductor content of all electronic products will continue to increase. The growth of digital technology, artificial intelligence, and multimedia applications will continue to create new opportunities. Future developments will lead to a much greater convergence of products and technologies with the expansion of the Internet and demand for global information networking.

### Sources of Additional Information

For information on the electronics industry, contact:

- The Electronic Industries Alliance 2500 Wilson Blvd., Arlington, VA 22201. Internet: <http://www.eia.org>
- American Electronics Association, The Center for Workforce Excellence, 5201 Great America Pkwy., Suite 520, Santa Clara, CA 95054. Internet: <http://www.aeanet.org>

For information on careers as an electrical, electronics, or computer engineer, contact:

- The Institute of Electrical and Electronics Engineers, Inc., 1828 L Street, NW., Suite 1202, Washington, DC 20036-5104.

For information on careers and training as an electronics technician, contact:

- Electronics Technicians Association, 602 North Jackson, Greencastle, IN 46135.

Information on these occupations may be found in the 2000-01 *Occupational Outlook Handbook*:

- Computer systems analysts, engineers, and scientists
- Electrical and electronics engineers
- Electronic semiconductor processors
- Engineering, natural science, and computer and information systems managers
- Engineering technicians
- Precision assemblers